WASHINGTON
SCIENCE TRENDS

HIGHLIGHTS

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* BIONICS PROGRAM REACHES HARDWARE PHASE

Hardware is now being assembled in a program for development of extremely small machines with biological complexity and near-biological intelligence. Ultimate volume of the machines apparently will be between one and several cubic inches, containing up to 10^{11} active elements, or about the same number as a highly developed biological system.

✓ Applications -- The machines, under development at Stanford Research Institute, would be designed to be carried by a human to aid him in solving complex problems at the time, and on the site at which they occur. They could also function in the most severe environments -- such as a vacuum, corrosive atmospheres, a furnace, under strong nuclear radiation fluxes, and under large accelerations. This would permit the machines to be closely coupled to the more energetic power systems and sent to almost any part of the solar system.

Another goal for these machines is to have them increase their capabilities by building improved machines with a minimum of human assistance. To accomplish this, the machine would need the ability to reorganize and expand its own functioning, and recognize methods by which its performance might be improved.

✓ Active Components -- Devices receiving the most consideration at Stanford as active components are based on quantum mechanical tunneling of electrons into a vacuum. These seem to be relatively insensitive to temperature changes and ionizing radiation -- and can be easily used in conjunction with other units needed by the complete machine, such as optical input and output devices. Tunnel effect components are now preferred by Stanford to film-type units such as cryotrons, magnetic devices and semiconductors.

✓ Plasma Systems -- First tests of assembled hardware will involve these tunnel effect components, but it is anticipated that work will eventually begin on plasma systems to replace them. These systems will, it is expected, overcome low binding energies inherent in any solid. It may be possible to construct plasma-like structures in which elementary particles are organized in dynamic equilibrium under the influence of applied fields.

✓ Progress -- The Stanford investigators predict that several more years will pass before the first of these ambitious machines can be constructed. However, nothing in the research to date shows that this general goal is unrealistic, or cannot be achieved in the relatively near future. Specifically, it is suggested that these advanced techniques will contribute strongly to the design of micromodule machines three generations from the present.

(A progress report entitled "Research in Microelectronics Using Electron-beam Activated Machining Techniques" available through military channels or at $3.50 from OTS, U. S. Department of Commerce, Washington 25, D. C.)

TECHNICAL TRENDS

□ The National Bureau of Standards will present three weeks of courses in radio propagation this summer, covering both tropospheric and ionospheric propagation. For details write E. H. Brown, Educational Director, Boulder Laboratories, National Bureau of Standards, Boulder, Colorado. √√√ New specifications for high-efficiency air filters are contained in Announcement No. 120 available from Safety and Fire Protection Branch, Office of Health and Safety, U.S. Atomic Energy Commission, Washington 25, D.C. √√√ Japanese photographic production, a matter of major concern to U.S. producers, rose 22 percent in the first 10 months of 1959. For details, write Information Office, Business and Defense Services Administration, Washington 25, D.C. for Announcement BD 61-24.

□ Wind tunnel tests by the National Aeronautics and Space Administration of a General Electric Co. lifting-fan engine installed in a full-scale model indicate that balance can be maintained in all phases of flight and forward speeds. NASA researchers had expected to meet with serious control difficulties, particularly during transition from hovering to forward flight. √√√ Vitro Laboratories, Silver Spring, Md. has received a substantial Navy contract for research, analytical investigations, evaluation, design of models and establishment of requirements for the development of Typhon missiles and components. √√√ All-American Engineering Co., Wilmington, Delaware, has received a contract for a safety tailhook on a KC-135 aircraft, in the second phase of a Federal Aviation Agency program designed to eliminate transport aircraft accidents due to aborted takeoffs and overshot landings.

□ Thermodynamic data on helium, hydrogen, neon and nitrogen gas will now be "published" on magnetic tape for direct introduction into a computer. Details are available from the Cryogenic Engineering Laboratory, Boulder Laboratories, National Bureau of Standards, Boulder, Colorado. √√√ Chicago Aerial Industries, Barrington, Ill. is producing 1,000 KE-28A "Spotter" cameras designed to be used by untrained Naval personnel to collect evidence of intrusion of U. S. radar, missile-firing and other coastal installations by submarines, "fishing" trawlers and other Soviet vessels. √√√ Fersmite, a rare columbium mineral previously found only in the Soviet Union, has also been discovered in Montana. A report (No. 5693) is available free from the U.S. Bureau of Mines, Publications-Distribution Office, 4800 Forbes Avenue, Pittsburgh 13, Pennsylvania.

□ Additional business opportunities in procurement, production and loans will be available to certain firms in labor surplus areas through a new regulation increasing by 25 percent the size standards for small businesses established by the Small Business Administration. √√√ Planning, Communication and Financing for Research and Development will be discussed at an American University seminar, in Washington, April 24-28. Details are available from Prof. L. H. Hattery, 1901 F Street, N. W., Washington 6, D. C.

ROYALTY-FREE PATENT

The following invention, developed at U. S. Government expense, is now available to U. S. industry, royalty - Free. For patent number and details on licensing, write Service Department, Washington Science Trends, Washington 4, D. C.

□ Limit Switch for Tape Recorders -- The patent covers a switch assembly which will automatically stop a tape at a specific point. It could be particularly useful for timing purposes, in missile programming or recording and transmission of information on satellites.

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* SPECIAL SUMMARY REPORT -- SPACE MATERIALS

Here is a Special Summary Report, from official sources, of some key aspects of the space structure materials research program of the National Aeronautics and Space Administration (NASA):

✓ High Temperature Materials -- Satisfactory performance of materials at high temperatures continues as one of the most serious technical problems confronting space research. Present nickel and cobalt-base superalloys, it is reported, are useful only up to about 1800° - 2100° F. For higher temperatures, attention is being given to such refractory materials as niobium, tantalum and tungsten.

For some time, the Langley (Va.) Research Center has been investigating fabrication and coating problems associated with molybdeum alloy sheet. More recent studies have turned to fabrication of tungsten sheet, and tantalum-tungsten alloy sheet. Preliminary results are said to indicate that currently available commercial tungsten sheet is too brittle and subject to layer separation or delamination for fabrication into the intricate shapes required. However, tantalum-tungsten alloy sheet apparently presents no forming problems.

✓ High Temperature Coatings -- NASA is interested in materials such as stainless steel or the nickel and cobalt-based alloys which develop protective oxides that inhibit oxidation at high temperatures. The oxides of the refractory metals are too unstable, and tend to volatize when at their proposed use temperatures. When this occurs, new metals are continually exposed to further oxidation. One possible way of handling this problem is to apply a coating to the metal. NASA studies have not yet turned up any outstanding commercially available coatings for protecting tungsten and tantalum-tungsten alloy sheet in the 2000° F to 3000° F temperature range.

To support this program, theoretical studies are underway to determine precisely why surface oxides are instable and volatile. Special attention has been directed to molybdenum trioxide. NASA officials express some hope that suitable alloying will prevent the metal from oxidizing rapidly at elevated temperatures.

✓ Surface Emissivities -- The abilities of various materials to cool themselves by radiating heat is under study by NASA laboratories. A special black-body furnace has been developed for determining emissivities for materials such as ceramics that cannot be heated by electrical resistance methods. An early part of the study was devoted to boron nitride, a high temperature material that displays good oxidation resistance and is semitransparent to heat radiation. Techniques are being devised to allow measurements of coated refractory metals.

✓ Fatigue Characteristics -- The rate at which cracks occur and propagate is an important field of study. Recent tests have shown that when aluminum-alloy sheet specimens are subjected to repeated steady pressures or stresses, an appreciable delay in crack propagation is encountered -- which is followed by a resumption at a lower rate when the stress amplitude is reduced.

✓ Micrometeoroid Impacts -- The effects of meteoroid impact on the strength of space materials will be investigated by means of impact studies on stressed sheet material to determine how much stress such structures can withstand, with or without penetrations. In addition, a Scout rocket scheduled for launching early this year will carry an experiment in which penetrations on two thicknesses of stainless steel will be counted.

* SPECIAL SUMMARY REPORT -- SPACE MATERIALS (Continued)

✓ Cryogenic Propellant Tank Material -- Studies are being pursued to permit rocket fuel tanks for space application to be made lighter without losing strength. Sheets of titanium alloys were tested by NASA; some were stronger (in terms of density to strength) and tougher at room temperatures than any of the best heat-treated steels now available. They also were found to stand up well at cryogenic temperatures.

In addition, several alloys each of aluminum, austenitic stainless steel and titanium have been tested at cryogenic temperatures. However, NASA investigators found that while it is possible to state tentatively which are the better alloys of each metal, they cannot state which metal is most promising for minimum weight application. This is because the strongest alloys are also the hardest to work, and are most affected by welds, holes and pipe fittings. NASA has designed equipment to test small-scale propellant tanks at temperatures down to -423° F.

✓ Nozzle Materials for Solid Propellant Rockets -- Tests at NASA's Lewis Research Center have centered on tungsten, high density graphite, molybdenum and certain ablating materials for use as rocket nozzles with non-aluminized (4800° F) and aluminized(5600° F) propellants. Results indicate that tungsten could best resist erosion. Tests are continuing on recently developed propellants which can achieve temperatures as high as 6300° F.

Manned Space Cabin Design

NASA has been investigating two distinctly different designs for manned space cabins -- a rigid structure and a structure which is folded during launch and erected in space, with an inner "package" to protect an astronaut until the main structure opens. Some recent studies:

✓ Erectable Structures -- Preliminary packaging and inflation tests by NASA with small models indicate that a toroid or doughnut-shaped structure to provide living quarters of a given volume in space could easily be packaged in approximately 8 percent of that volume. Work will be continued on 10 and 30 foot diameter toroid models.

NASA study contracts with Goodyear Aircraft Company, Akron, Ohio, completed in late 1960, called for preliminary evaluation of inflatable fabric materials, detailed studies of elastomers with emphasis on effects of temperature, vacuum and ultraviolet radiation; studies to determine the best methods of folding materials and structural design and analysis to determine favorable torus configurations or shapes, and accomplish preliminary design of attachments, seams, and feed-throughs for lines and cables. Based on these studies, 3-ply fabrics have been developed that are composed of neoprene or butyl rubber elastomers and nylon or dacron cord reinformcements. The fabrics, according to NASA, meet stress, folding and weight requirements, and could survive in space for at least 30 days. NASA research centers are testing elastomers, reinforcing cords and protective coatings designed to last for longer periods -- six months or more.

✓ Rigid Space Cabins -- An apparently unavoidable weakness inherent in thin-shelled cylindrical structures has been detected by studies of rigid space cabin designs. NASA has tested a number of large cylinders of this type, with and without ring stiffeners. Measured strengths agreed with theoretical predictions for high internal pressures, but were much lower than predicted for lower internal pressures. This would ordinarily be attributed to manufacturing imperfections. However, the "inherent and apparently unavoidable" weakness in such structures is now suspect.

RESEARCH CHECKLIST

□ RARE EARTH BORATES: The National Bureau of Standards is studying the polymorphic crystalline states of rare earth borates, in an investigation which may be of value in the field of high-temperature ceramics. The melting points of these borates are above that of boric oxide, and phase studies have shown that some of these compounds exist in equilibrium with liquid boric oxide above 1400° C. Thus, the Bureau states, a rare earth borate ceramic could be used where resistance to attack by boric oxide is important.

(Further details available. Write National Bureau of Standards, Office of Technical Information, Washington 25, D.C. regarding "Polymorphism of Rare Earth Borates")

□ FILTERING DUST FROM GASES: The U.S. Bureau of Mines has developed laboratory methods of filtering dust from gases at 1800° F as a step in developing new processes that use coal as a raw material. Tests demonstrated that an aluminum silicate fiber filter could be used indefinitely, and that such fibers will not react with the environment -- the dust, inert carrier gas or the filter tube. The fiber, commercially available, contains 51.3 percent aluminum oxide, 45.3 silica and 3.4 percent zirconium oxide.

(Technical details available. Single Copies Free. Write U.S. Bureau of Mines, Publications Distribution Office, 4800 Forbes Avenue, Pittsburgh 13, Pa. for Report of Investigation No. 5672)

□ MEASURING SOUND IN STEAM: The Navy has sponsored construction of an apparatus to measure the velocity and attenuation of sound in steam. Measurements are currently being carried out on steam at pressures of 1000 pounds per square inch, and temperatures as high as 750° F, using a variable-path interometer. Work at higher pressures and temperatures is planned as part of a basic program on physical acoustics.

(R&D by James Woodburn, North Carolina State College, Raleigh, N.C., sponsored by the Office of Naval Research)

□ INSTRUMENTS AND CONTROL SYSTEMS FOR SPACE VEHICLES: Study of conventional and unconventional flight instruments for a space vehicle which can change orbits in space, intercept another satellite, re-enter the earth's atmosphere and glide to a controlled landing at a specific airfield has been made by Hughes Aircraft Company for the Air Force. An extremely detailed report of this study describes several types of instruments which could keep the pilot of a space vehicle appraised of his position relative to other objects in a three-dimensional display. It also discusses in detail the maneuvering and control functions that the pilot will be able to handle, even on an emergency basis, and the type of control which will be necessary to perform those functions of which he is incapable.

(WADD Technical Report 60-197 available through military channels or for $3.50 from OTS, U.S. Dept. of Commerce, Washington 25, D.C.)

□ CARBON DIOXIDE REMOVAL: Studies by the Navy indicate that lithium hydroxide offers the greatest advantage as the basis of an emergency carbon dioxide removal system for submarines. A system recently developed employs a self-enclosed filter-blower apparatus holding five canisters, each with six pounds of lithium hydroxide which, under normal conditions, will absorb the CO_2 produced by 35-40 men over an 8 hour period. A commercially designed version is said to be about ready for fleet use.

(R&D reported by S. J. Smith, Jr., Chemistry Division, Inorganic and Nuclear Chemistry Branch, U.S. Naval Research Laboratory, Washington 25, D.C.)

DISMATIC

ARC-5563

P U B L I C A T I O N C H E C K L I S T

- ATOMIC ENERGY RESEARCH, an excellent special report by the Atomic Energy Commission devoted to basic research in the medical and biological fields and in the physical sciences -- high energy physics, metallurgy, chemistry and controlled thermonuclear research. Also includes a list of references on fallout, a summary of current AEC unclassified research contracts and related information. 175 Pages. $1.25. (Write Superintendent of Documents, Government Printing Office, Washington 25, D.C. for "Atomic Energy Research in the Life and Physical Sciences - 1960")

- ENERGY RESOURCES AND GOVERNMENT, a useful compilation of materials from federal and state regulatory and developmental agencies concerned with oil, gas and various other energy resources. 603 Pages. (Write Chairman, Joint Economic Committee, U.S. Congress, Washington 25, D.C.)

- SMALL BUSINESS PROBLEMS, a critical Congressional report on Government policies including a chapter which cites the "alarming" decline in the small business share of the Defense Department's expenditures for research. 209 Pages. Single Copies Free. (Write Select Committee on Small Business, U.S. House of Representatives, The Capitol, Washington 25, D.C. for House Report No. 2235)

- RADIANT-HEAT-TRANSFER PROCESSES, a "short instruction course" designed to help scientists and design engineers meet the increasing demand for knowledge of radiant-heat-transfer imposed by enlarging missile and space technology. (Available through military channels or at 50 cents from OTS, U.S. Department of Commerce, Washington 25, D.C. Ask for DMIC Memorandum No. 72)

- HANDBOOK FOR HYDROGEN HANDLING EQUIPMENT, prepared for the Air Force by Arthur D. Little, Inc., provides engineering data on storage, transfer and ground servicing systems. Specifies requirements for storage vessels, transfer lines, pumping systems valves, instruments and recondensing systems. 589 Pages. (Available through military channels or at $7 from OTS, U.S. Department of Commerce, Washington 25, D.C.)

- ACADEMIC DEGREES, a directory of earned and honorary degrees conferred by U.S. institutions of higher education. 324 Pages. $1. (Write Superintendent of Documents, Government Printing Office, Washington 25, D.C. for Pub. No. FS 5.254:54008)

- PERFORMANCE CHARTS FOR MULTISTAGE ROCKET BOOSTERS, a collection of technical charts relating the stage propellant fractions for two and three-stage rockets launching payloads into nominal low-altitude circular earth orbits. Also includes a simple method for extending these data to higher orbit or escape missions. 90 Pages. Single Copies Free. (Write National Aeronautics and Space Administration, 1520 H Street, N.W., Washington 25, D.C. ATTN: CODE BID, for NASA Technical Note D-582)

- INDUSTRIAL RESEARCH AND DEVELOPMENT FUNDS, a study by the National Science Foundation purporting to show that funds for performance of R&D by American industry increased by 15 percent in 1959 and probably reached $10 billion in 1960. 7 Pages. 10 Cents. (Write Superintendent of Documents, Government Printing Office, Washington 25, D.C. for Publication NSF -60-81)

- "RESEARCH ATMOSPHERE", a listing of books, articles and some unpublished material designed to aid "in attacking the bedeviling problem of providing the optimum research atmosphere". 8 Pages. Single Copies Free. (Write Information Office, Office of Ordnance Research, U.S. Army, Box CM, Duke Station, Durham, N.C.)